but under the circumstances nothing was done. He and others made observations of the appearance of the sky, &c., but nothing of importance was noted.

With the exception of the want of sunshine for adjustment all the arrangements made answered well. The time at our disposal for setting up the instruments was hardly enough, partly owing to the above reason, but the days were very long, and under ordinary circumstances the time would not have been enough.

The instruments all went well. From want of experience in eclipse work I cannot speak with authority on the matter, but I think that there can be no doubt that the cœlostat is the proper instrument for eclipse work. I can easily see the very great additional work we should have had to do if we had been using equatorial mountings. A great improvement might be made by housing the whole of the apparatus under one roof, suitable openings being left for the requisite sky to be seen from the cœlostat.

The arrangement I used with the large lens for sliding the plate-holder along in a frame is very much better than the plan in use with the twin telescope of putting in and taking out each plate-holder separately, a plan necessary in the case of the equatorial mounting for which the twin telescopes were made ; but if these are to be used again a sliding arrangement should be used, and I am not sure that it would not be better to still further reduce the hand movement necessary now to expose successive plates by having a mechanical arrangement to do all when once started.

Another point. This eclipse shows that all available stations should be occupied if possible ; in this case it would have been well if Bodö had been occupied. On going up the coast I observed the sky in the early morning, and found it very fine indeed, and had it been possible I should have left part of my party at Bodö, Mr. Hinks, in the right scientific spirit, expressing his willingness to forego the pleasures of the longer voyage and to stay there if required. The difficulty of dealing with the instruments separately, however, prevented this being done ; nor could I induce any of the many observers on board to stay behind.

Report to the Joint Eclipse Committee on the Expedition to Kiö Island. By Professor J. Norman Lockyer, C.B., F.R.S.

The party consisted of Mr. Fowler, Dr. W. J. S. Lockyer, and myself. As it was impossible for me to leave London before July 22, Mr. Fowler and Dr. W. J. S. Lockyer went on in advance and joined H.M.S. *Volage* at Hammerfest on July 22,

and left the following day for the Varanger Fjord. On July 24 they were landed at Bras Havn, and spent two days in exploring the neighbourhood for a suitable site.

The erection of the instruments was commenced on July 27, and on my arrival at Kiö Island a week later most of them were in adjustment and ready for the eclipse.

The main objects of the expedition were to photograph the spectra of the solar surroundings with prismatic cameras of 6 and 9 inches aperture, and with an integrating spectroscope having two 3-inch prisms of 60°. In addition, about seventy officers and men of H.M.S. *Volage* were trained to make drawings, read thermometers, note the colours of the landscape, &c., and to assist in the manipulation of the larger instruments.

On the morning of the eclipse the sky was almost entirely overcast, the Sun only being visible for a few seconds during the partial phases, so that all work with the instruments was impossible.

Some useful observations of temperature, landscape colours, &c., were secured by the *Volage* observers; and a report upon these, together with a description of the instruments and observing station, will be communicated to the Committee in due course.

To meet the cost of this section of the expedition, including partial instrumental equipment, a grant of 200*l.* was made by the Eclipse Committee. The accounts are not yet completed, as some of the instruments were slightly damaged and the repairs are not finished. The sum granted, however, has certainly not been exceeded, and it is expected that a few pounds will be left over to return to the Committee.

Thanks are due to the Norwegian Government for permission to land on the south side of the Varanger Fjord, to Captain King-Hall, R.N., and the officers and men of H.M.S. *Volage*, who rendered such splendid assistance during the preparations for the eclipse, and to the Orient Steam Navigation Company for the free carriage of some of the instruments, and for twice altering the course of the s.s. *Garonne* to permit landing and embarking off Kiö.

On arriving home I at once communicated to the Royal Society the efficient aid rendered by the officers and men of the *Volage*, as the captain and a large proportion of the crew were to leave the ship on her reaching port.

On the Variation of Uncanonical Arbitrary Constants; with an application to the Planetary Theory. By A. Y. G. Campbell, B.A., Scholar of Trinity College, Cambridge.

(*Communicated by Sir R. S. Ball.*)

In attacking the planetary or lunar theories by the method of the variation of arbitrary constants, it is necessary to evaluate several functions usually denoted by $[a, e]$, &c., unless a canonical set of arbitrary constants is chosen. In this paper I endeavour to show that the equations giving the variations of these constants can be found more quickly without evaluating the functions $[a, e]$, &c. It is necessary to find one function (denoted in this paper by C with a suffix) corresponding to each arbitrary constant. In the first two sections the theory and its application to the elliptic constants of the planetary theory are briefly explained. In the following section it is shown that if any solution of the new equations is found we can proceed to find the equations, giving the variation of the new arbitrary constants. The next approximation can be obtained in a manner similar to that used in the previous case. It is shown also in the last section that in certain cases there exists a method of solution similar to Jacobi's method of solution of the Hamiltonian canonical equations. Among these cases is included the set of equations giving the variations of the elliptic elements in the planetary theory.

§ 1.

Let $\alpha_1, \alpha_2, \ldots \alpha_{2n}$ be the set of arbitrary constants of any solution of the canonical equations

$$\dot{q}_i = \frac{d\mathrm{H}}{dp_i}, \quad -\dot{p}_i = \frac{d\mathrm{H}}{dq_i} (i = 1, 2, \ldots n) \quad \ldots\ldots\ldots \quad (1)$$

It is required to find the equations giving the rates of variation of $\alpha_1, \alpha_2, \ldots \alpha_{2n}$ when a disturbing function Ω is added to H.

If L is the Lagrangian function corresponding to H,

$$\frac{d\mathrm{L}}{d\dot{q}_i} = p_i, \quad \frac{d\mathrm{L}}{dq_i} = \dot{p}_i (i = 1, 2, \ldots n);$$

and if α_r is one of the arbitrary constants in terms of which L is supposed to be expressed,

$$\begin{aligned} \frac{d\mathrm{L}}{d\alpha_r} &= \sum_{i=1}^{i=n} \left(\frac{d\mathrm{L}}{dq_i} \frac{dq_i}{d\alpha_r} + \frac{d\mathrm{L}}{d\dot{q}_i} \frac{d\dot{q}_i}{d\alpha_r} \right) \\ &= \sum_{i=1}^{i=n} \left(\dot{p}_i \frac{dq_i}{d\alpha_r} + p_i \frac{d\dot{q}_i}{d\alpha} \right) \\ &= \frac{d}{dt} \left(\sum_{i=1}^{i=n} p_i \frac{dq_i}{d\alpha_r} \right) \end{aligned}$$